



# Certificate of Grant of Patent

Patent Number: GB2415004  
Proprietor(s): Enventure Global Technology  
Inventor(s): Mark Shuster  
Scott Costa

*This is to Certify that, in accordance with the Patents Act 1977,*

a Patent has been granted to the proprietor(s) for an invention entitled  
**"Apparatus and method radially expanding a wellbore casing using  
an expansion mandrel and a rotary expansion tool"** disclosed in an  
application filed **15 March 2004**.

Dated 13 December 2006



**Ron Marchant**  
*Comptroller General of Patents,  
Designs and Trade Marks*  
**UNITED KINGDOM PATENT OFFICE**



(12) **UK Patent** (19) **GB** (11) **2 415 004** (13) **B**

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(54) Title of the invention: **Apparatus and method radially expanding a wellbore casing using an expansion mandrel and a rotary expansion tool**

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**APPARATUS AND METHOD FOR RADially EXPANDING A WELLBORE CASING USING  
AN EXPANSION MANDREL AND A ROTARY EXPANSION TOOL**

**Cross Reference To Related Applications**

[001] The present application is the National Stage patent application for PCT patent application serial number PCT/US2004/008171, attorney docket number 25791.236.02, filed on 3/15/2004, which claimed the benefit of the filing dates of (1) U.S. provisional patent application serial no. 60/454,896, attorney docket no. 25791.236, filed on March 14, 2003, the disclosures of which are incorporated herein by reference.

The present application is related to the following: (1) U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, which claims priority from provisional application 60/121,702, filed on 2/25/99, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, which claims priority from provisional application 60/119,611, filed on 2/11/99, (4) U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (5) U.S. patent application serial no. 10/169,434, attorney docket no. 25791.10.04, filed on 7/1/02, which claims priority from provisional application 60/183,546, filed on 2/18/00, (6) U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (7) U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (8) U.S. patent number 6,575,240, which was filed as patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, which claims priority from provisional application 60/121,907, filed on 2/26/99, (9) U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (10) U.S. patent application serial no. 09/981,916, attorney docket no. 25791.18, filed on 10/18/01 as a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (11) U.S. patent number 6,604,763, which was filed as application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, which claims priority from

provisional application 60/131,106, filed on 4/26/99, (12) U.S. patent application serial no. 10/030,593, attorney docket no. 25791.25.08, filed on 1/8/02, which claims priority from provisional application 60/146,203, filed on 7/29/99, (13) U.S. provisional patent application serial no. 60/143,039, attorney docket no. 25791.26, filed on 7/9/99, (14) U.S. patent application serial no. 10/111,982, attorney docket no. 25791.27.08, filed on 4/30/02, which claims priority from provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (15) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (16) U.S. provisional patent application serial no. 60/438,828, attorney docket no. 25791.31, filed on 1/9/03, (17) U.S. patent number 6,564,875, which was filed as application serial no. 09/679,907, attorney docket no. 25791.34.02, on 10/5/00, which claims priority from provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (18) U.S. patent application serial no. 10/089,419, filed on 3/27/02, attorney docket no. 25791.36.03, which claims priority from provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (19) U.S. patent application serial no. 09/679,906, filed on 10/5/00, attorney docket no. 25791.37.02, which claims priority from provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (20) U.S. patent application serial no. 10/303,992, filed on 11/22/02, attorney docket no. 25791.38.07, which claims priority from provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (21) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (22) U.S. provisional patent application serial no. 60/455,051, attorney docket no. 25791.40, filed on 3/14/03, (23) PCT application US02/2477, filed on 6/26/02, attorney docket no. 25791.44.02, which claims priority from U.S. provisional patent application serial no. 60/303,711, attorney docket no. 25791.44, filed on 7/6/01, (24) U.S. patent application serial no. 10/311,412, filed on 12/12/02, attorney docket no. 25791.45.07, which claims priority from provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (25) U.S. patent application serial no. 10/, filed on 12/18/02, attorney docket no. 25791.46.07, which claims priority from provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (26) U.S. patent application serial no. 10/322,947, filed on 1/22/03, attorney docket no. 25791.47.03, which claims priority from provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (27) U.S. patent application serial no. 10/406,648, filed on 3/31/03, attorney docket no. 25791.48.06, which claims priority from provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (28) PCT application US02/04353, filed on 2/14/02, attorney docket no. 25791.50.02, which claims priority from U.S.

provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001, (29) U.S. patent application serial no. 10/465,835, filed on 6/13/03, attorney docket no. 25791.51.06, which claims priority from provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001, (30) U.S. patent application serial no. 10/465,831, filed on 6/13/03, attorney docket no. 25791.52.06, which claims priority from U.S. provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001, (31) U.S. provisional patent application serial no. 60/452,303, filed on 3/5/03, attorney docket no. 25791.53, (32) U.S. patent number 6,470,966, which was filed as patent application serial number 09/850,093, filed on 5/7/01, attorney docket no. 25791.55, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (33) U.S. patent number 6,561,227, which was filed as patent application serial number 09/852,026, filed on 5/9/01, attorney docket no. 25791.56, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (34) U.S. patent application serial number 09/852,027, filed on 5/9/01, attorney docket no. 25791.57, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (35) PCT Application US02/25808, attorney docket no. 25791.58.02, filed on 8/13/02, which claims priority from provisional application 60/318,021, filed on 9/7/01, attorney docket no. 25791.58, (36) PCT Application US02/24399, attorney docket no. 25791.59.02, filed on 8/1/02, which claims priority from U.S. provisional patent application serial no. 60/313,453, attorney docket no. 25791.59, filed on 8/20/2001, (37) PCT Application US02/29856, attorney docket no. 25791.60.02, filed on 9/19/02, which claims priority from U.S. provisional patent application serial no. 60/326,886, attorney docket no. 25791.60, filed on 10/3/2001, (38) PCT Application US02/20256, attorney docket no. 25791.61.02, filed on 6/26/02, which claims priority from U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, (39) U.S. patent application serial no. 09/962,469, filed on 9/25/01, attorney docket no. 25791.62, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (40) U.S. patent application serial no. 09/962,470, filed on 9/25/01, attorney docket no. 25791.63, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no.

25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (41) U.S. patent application serial no. 09/962,471, filed on 9/25/01, attorney docket no. 25791.64, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (42) U.S. patent application serial no. 09/962,467, filed on 9/25/01, attorney docket no. 25791.65, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (43) U.S. patent application serial no. 09/962,468, filed on 9/25/01, attorney docket no. 25791.66, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (44) PCT application US 02/25727, filed on 8/14/02, attorney docket no. 25791.67.03, which claims priority from U.S. provisional patent application serial no. 60/317,985, attorney docket no. 25791.67, filed on 9/6/2001, and U.S. provisional patent application serial no. 60/318,386, attorney docket no. 25791.67.02, filed on 9/10/2001, (45) PCT application US 02/39425, filed on 12/10/02, attorney docket no. 25791.68.02, which claims priority from U.S. provisional patent application serial no. 60/343,674, attorney docket no. 25791.68, filed on 12/27/2001, (46) U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (47) U.S. utility patent application serial no. 10/516,467, attorney docket no. 25791.70, filed on 12/10/01, which is a continuation application of U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (48) PCT application US 03/00609, filed on 1/9/03, attorney docket no. 25791.71.02, which claims priority from U.S. provisional patent application serial no. 60/357,372, attorney docket no. 25791.71, filed on 2/15/02, (49) U.S. patent application serial no. 10/074,703, attorney docket no. 25791.74, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (50) U.S. patent application serial no. 10/074,244, attorney docket no. 25791.75, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent

application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (51) U.S. patent application serial no. 10/076,660, attorney docket no. 25791.76, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (52) U.S. patent application serial no. 10/076,661, attorney docket no. 25791.77, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (53) U.S. patent application serial no. 10/076,659, attorney docket no. 25791.78, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (54) U.S. patent application serial no. 10/078,928, attorney docket no. 25791.79, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (55) U.S. patent application serial no. 10/078,922, attorney docket no. 25791.80, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (56) U.S. patent application serial no. 10/078,921, attorney docket no. 25791.81, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (57) U.S. patent application serial no. 10/261,928, attorney docket no. 25791.82, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (58) U.S. patent application serial no. 10/079,276, attorney docket no. 25791.83, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (59) U.S. patent application serial no. 10/262,009, attorney docket no. 25791.84, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which



claims priority from provisional application 60/137,998, filed on 6/7/99, (60) U.S. patent application serial no. 10/092,481, attorney docket no. 25791.85, filed on 3/7/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (61) U.S. patent application serial no. 10/261,926, attorney docket no. 25791.86, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (62) PCT application US 02/36157, filed on 11/12/02, attorney docket no. 25791.87.02, which claims priority from U.S. provisional patent application serial no. 60/338,996, attorney docket no. 25791.87, filed on 11/12/01, (63) PCT application US 02/36267, filed on 11/12/02, attorney docket no. 25791.88.02, which claims priority from U.S. provisional patent application serial no. 60/339,013, attorney docket no. 25791.88, filed on 11/12/01, (64) PCT application US 03/11765, filed on 4/16/03, attorney docket no. 25791.89.02, which claims priority from U.S. provisional patent application serial no. 60/383,917, attorney docket no. 25791.89, filed on 5/29/02, (65) PCT application US 03/15020, filed on 5/12/03, attorney docket no. 25791.90.02, which claims priority from U.S. provisional patent application serial no. 60/391,703, attorney docket no. 25791.90, filed on 6/26/02, (66) PCT application US 02/39418, filed on 12/10/02, attorney docket no. 25791.92.02, which claims priority from U.S. provisional patent application serial no. 60/346,309, attorney docket no. 25791.92, filed on 1/7/02, (67) PCT application US 03/06544, filed on 3/4/03, attorney docket no. 25791.93.02, which claims priority from U.S. provisional patent application serial no. 60/372,048, attorney docket no. 25791.93, filed on 4/12/02, (68) U.S. patent application serial no. 10/331,718, attorney docket no. 25791.94, filed on 12/30/02, which is a divisional U.S. patent application serial no. 09/679,906, filed on 10/5/00, attorney docket no. 25791.37.02, which claims priority from provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (69) PCT application US 03/04837, filed on 2/29/03, attorney docket no. 25791.95.02, which claims priority from U.S. provisional patent application serial no. 60/363,829, attorney docket no. 25791.95, filed on 3/13/02, (70) U.S. patent application serial no. 10/261,927, attorney docket no. 25791.97, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (71) U.S. patent application serial no. 10/262,008, attorney docket no. 25791.98, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no.

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09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (72) U.S. patent application serial no. 10/261,925, attorney docket no. 25791.99, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (73) U.S. patent application serial no. 10/199,524, attorney docket no. 25791.100, filed on 7/19/02, which is a continuation of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (74) PCT application US 03/10144, filed on 3/28/03, attorney docket no. 25791.101.02, which claims priority from U.S. provisional patent application serial no. 60/372,632, attorney docket no. 25791.101, filed on 4/15/02, (75) U.S. provisional patent application serial no. 60/412,542, attorney docket no. 25791.102, filed on 9/20/02, (76) PCT application US 03/14153, filed on 5/6/03, attorney docket no. 25791.104.02, which claims priority from U.S. provisional patent application serial no. 60/380,147, attorney docket no. 25791.104, filed on 5/6/02, (77) PCT application US 03/19993, filed on 6/24/03, attorney docket no. 25791.106.02, which claims priority from U.S. provisional patent application serial no. 60/397,284, attorney docket no. 25791.106, filed on 7/19/02, (78) PCT application US 03/13787, filed on 5/5/03, attorney docket no. 25791.107.02, which claims priority from U.S. provisional patent application serial no. 60/387,486, attorney docket no. 25791.107, filed on 6/10/02, (79) PCT application US 03/18530, filed on 6/11/03, attorney docket no. 25791.108.02, which claims priority from U.S. provisional patent application serial no. 60/387,961, attorney docket no. 25791.108, filed on 6/12/02, (80) PCT application US 03/20694, filed on 7/1/03, attorney docket no. 25791.110.02, which claims priority from U.S. provisional patent application serial no. 60/398,061, attorney docket no. 25791.110, filed on 7/24/02, (81) PCT application US 03/20870, filed on 7/2/03, attorney docket no. 25791.111.02, which claims priority from U.S. provisional patent application serial no. 60/399,240, attorney docket no. 25791.111, filed on 7/29/02, (82) U.S. provisional patent application serial no. 60/412,487, attorney docket no. 25791.112, filed on 9/20/02, (83) U.S. provisional patent application serial no. 60/412,488, attorney docket no. 25791.114, filed on 9/20/02, (84) U.S. patent application serial no. 10/280,356, attorney docket no. 25791.115, filed on 10/25/02, which is a continuation of U.S. patent number 6,470,966, which was filed as patent application serial number 09/850,093, filed on 5/7/01, attorney docket no. 25791.55, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which

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[002] This invention relates generally to oil and gas exploration, and in particular to forming and repairing wellbore casings to facilitate oil and gas exploration.

#### Background of the Invention

[003] Conventionally, when a wellbore is created, a number of casings are installed in the borehole to prevent collapse of the borehole wall and to prevent undesired outflow of drilling fluid into the formation or inflow of fluid from the formation into the borehole. The borehole is drilled in

intervals whereby a casing which is to be installed in a lower borehole interval is lowered through a previously installed casing of an upper borehole interval. As a consequence of this procedure the casing of the lower interval is of smaller diameter than the casing of the upper interval. Thus, the casings are in a nested arrangement with casing diameters decreasing in downward direction. Cement annuli are provided between the outer surfaces of the casings and the borehole wall to seal the casings from the borehole wall. As a consequence of this nested arrangement a relatively large borehole diameter is required at the upper part of the wellbore. Such a large borehole diameter involves increased costs due to heavy casing handling equipment, large drill bits and increased volumes of drilling fluid and drill cuttings. Moreover, increased drilling rig time is involved due to required cement pumping, cement hardening, required equipment changes due to large variations in hole diameters drilled in the course of the well, and the large volume of cuttings drilled and removed.

The present invention is directed to overcoming one or more of the limitations of the existing procedures for forming and/or repairing wellbore casings.

#### Summary of the Invention

According to a first aspect of the present invention there is provided apparatus for radially expanding and plastically deforming a tubular member, comprising:

a first expansion device for controllably straining the tubular member; and

a second expansion device for controllably stressing the tubular member, the first and second expansion devices being coupled for conjoint movement through substantially the entire length of the tubular member to be radially expanded and plastically deformed.

Preferably, the apparatus further comprises:

a tubular support member defining a first passage;

wherein the first expansion device comprises a tubular expansion cone defining a second passage coupled to the tubular support member;

wherein the apparatus further comprises a fluid driven motor coupled to the tubular expansion cone comprising an inlet;

wherein the second expansion device comprises a rotary expansion device coupled to the output shaft of the fluid driven motor;

wherein the first passage is operably coupled to the second passage; and

wherein the second passage is operably coupled to the inlet of the fluid driven motor.

Preferably, the apparatus further comprises a motor coupled to the first expansion device for rotating the second expansion device relative to the first expansion device.

Preferably, the apparatus further comprises a motor coupled to the first expansion device for displacing the second expansion device relative to the first expansion device.

Preferably, the interface between the first expansion device and the tubular member is not fluid tight; and the apparatus further comprising:

means for pulling the first expansion device through the tubular member.

Preferably, the apparatus further comprises a hydroforming device for radially expanding and plastically deforming the tubular member.

Preferably, at least one of the first and second expansion devices is adjustable in size.

Preferably, the tubular member comprises a pipeline.

Preferably, the tubular member comprises a structural support.

Preferably, the interface between the first expansion device and the tubular member is not fluid tight;

wherein the apparatus further comprises:

means for pulling the first expansion device through the tubular member; and

a hydroforming device for radially expanding and plastically deforming the tubular member;

wherein at least one of the first and second expansion devices is adjustable in size; and

wherein the tubular member comprises at least one of a pipeline or a structural support.

According to another aspect of the present invention, there is provided a method of radially expanding and plastically deforming a tubular member, comprising:

controllably straining the tubular member; and

controllably stressing the tubular member,

the controllably straining and controllably stressing steps being simultaneously performed progressively along substantially the entire length of the tubular member to be radially expanded and plastically deformed.

Preferably, controllably stressing the tubular member is performed by:

controllably stressing a longitudinal portion of the tubular member before controllably straining the longitudinal portion of the tubular member.

Preferably, the method further comprises radially expanding and plastically deforming the tubular member using fluidic pressure.

Preferably, the tubular member comprises a pipeline.

Preferably, the tubular member comprises a structural support.

Preferably, controllably stressing the tubular member is performed by:

controllably stressing a longitudinal portion of the tubular member after controllably straining the longitudinal portion of the tubular member;

wherein the method further comprises radially expanding and plastically deforming the tubular member using fluidic pressure; and

wherein the tubular member comprises at least one of a pipeline or structural support.

Preferably, controllably stressing the tubular member is performed by:

controllably stressing a longitudinal portion of the tubular member after controllably straining the longitudinal portion of the tubular member.

According to another aspect of the present invention, there is provided a system for radially expanding and plastically deforming a tubular member, comprising:

means for controllably straining the tubular member;

means for controllably stressing the tubular member; and

means for linking the means for controllably straining and the means for controllably stressing for conjoint movement through substantially the entire length of the tubular member to be radially expanded and plastically deformed.

Preferably, means for controllably stressing the tubular member comprises:

means for controllably stressing a longitudinal portion of the tubular member before controllably straining the longitudinal portion of the tubular member.

Preferably, means for controllably stressing the tubular member comprises:

means for controllably stressing a longitudinal portion of the tubular member after controllably straining the longitudinal portion of the tubular member.

#### **Brief Description of the Drawings**

Fig. 1 is a fragmentary cross sectional illustration of an exemplary embodiment of an apparatus for radially expanding a tubular member.

#### **Detailed Description of the Illustrative Embodiments**

Referring to Fig. 1, an exemplary embodiment of an apparatus 100 for radially expanding a tubular member includes a tubular support member 102 that defines a passage 102a. An end of an expansion mandrel 104 that defines a passage 104a, a chamber 104b, and a passage 104c is coupled to an end of the tubular support member 102 that includes a tapered outer surface 104d.

A conventional mud motor 106 is positioned within the chamber 104b of the mandrel 104 that includes an rotatable output shaft 106a that extends out of the mandrel. In an exemplary embodiment, the inlet of the mud motor 106 is fluidically coupled to the passage 104a of the



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mandrel, and the outlet of the mud motor is fluidically coupled to the passage 104c of the mandrel. In this manner, the mud motor 106 may be operated to rotate the shaft 106a upon pumping fluidic materials into and through the mud motor. A conventional rotary expansion tool 108 is coupled to an end of the shaft 106a that may be any number of conventional commercially available rotary expansion devices such as, for example, the rotary expansion devices commercially available from Weatherford International or as described in one or more of the following: U.S. 6,457,532



and/or WO 02/081863 A1, the disclosures of which are incorporated herein by reference. In an exemplary embodiment, the rotary expansion tool 108 includes one or more circumferentially and/or axially spaced apart roller expansion elements 108a.

[004] The mandrel 104, the mud motor 106, and the rotary expansion tool 108 are housed within a tubular launcher assembly 110 that includes a shoe 110a, a tubular section 110b, and a tapered tubular section 110c. In an exemplary embodiment, the tubular section 110b of the tubular launcher assembly 110 mates with the mandrel 104 and the rotary expansion tool 108. An end of an expandable tubular 112 is coupled to the tapered tubular section 110c of the launcher assembly 110. In an exemplary embodiment, one or more cup seals 114 are coupled to the exterior of the tubular support 102 for sealingly engaging the interior surface of the expandable tubular member 112.

[005] In an exemplary embodiment, the apparatus is initially positioned within a borehole 116 that traverses a subterranean formation 118. Fluidic materials 120 are then injected into the apparatus 100 through the passages, 102a and 104a. The fluidic materials 120 are then conveyed into and through the mud motor 106 and out of the mandrel 104 through the passage 104c. As a result, the mud motor 106 is operated to thereby rotate the shaft 106a and the rotary expansion tool 108. Also, as a result, the interior portion of the launcher 110 below the mandrel 104 is pressurized thereby causing the mandrel, mud motor 106, and the rotary expansion tool 108 to be displaced upwardly relative to the launcher 110.

[006] The upward displacement of the mandrel 104, mud motor 106, and rotary expansion tool 108 then radially expands and plastically deforms at least the tubular section 110b and the tapered tubular section 110c of the launcher 110 and the expandable tubular member 112. In an exemplary embodiment, the tapered surface 104d of the expansion mandrel 104 provides the majority of the radial expansion and plastic deformation of the tapered tubular section 110c of the launcher 110 and the expandable tubular member 112. In an exemplary embodiment, the outside diameter of the rotary expansion tool 108 is adjustable and thereby permits the rotary expansion tool 108 to radially expand and plastically deform the expandable tubular member 112 into intimate contact with the walls of the borehole 114. As a result, the formation surrounding the expandable tubular member 112 may be compressed and, after the completion of the radial expansion and plastic deformation of the expandable tubular member, held in compression. In an exemplary embodiment, during the operation of the apparatus 100, the expansion mandrel 104 applies radial forces to contiguous circumferential interior surfaces of the tubular launcher assembly 110 and/or the expandable tubular member 112, and the rotary expansion tool 108 applies radial forces to discrete noncontiguous interior surfaces of the tubular launcher assembly

and/or the expandable tubular member.

**[007]** During the operation of the apparatus 100, in an exemplary embodiment, the expansion mandrel 104 provides a strain controlled radial expansion process, and the rotary expansion tool 108 provides a stress controlled radial expansion process. For example, the final inside diameter of the expandable tubular member 112 provided by operation of the expansion mandrel 104 is controlled by the shape and geometry of the expansion mandrel and should be constant. However, the final inside diameter of the expandable tubular member provided by operation of the rotary expansion tool 108 may, or may not, be constant depending upon the shape of the wellbore 116. In particular, the amount of strain of the expandable tubular member 112 provided by the rotary expansion tool 108 is not controlled. Rather, the amount of stress applied to the expandable tubular member 112 by the rotary expansion tool 108 is controlled by controlling the compliance of the roller expansion elements 108a. Consequently, in an exemplary embodiment, the operation of the rotary expansion tool 108 will cause the outside diameter of the expandable tubular member 112 to engage and thereby match the inside diametrical shape of the wellbore 116. A strain controlled radial expansion process is typically capable of providing more radial expansion and plastic deformation than a stress controlled radial expansion process. However, a stress controlled radial expansion process is typically more capable of expanding a tubular member into engagement with an irregularly shaped wellbore 116. Consequently, the combination of a strain controlled expansion process with a stress controlled expansion process provides the benefits of both in one radial expansion process.

**[008]** In several alternative embodiments, during the operation of the apparatus 100, the tubular support member 102, mandrel 104, and/or mud motor 106 are also rotated during the radial expansion and plastic deformation of the expandable tubular member 112. In several alternative embodiments, during the operation of the apparatus 100, the rotary expansion tool 108 is not rotated relative to the mandrel 104.

**[009]** In an alternative embodiment, the expansion mandrel 104 is pulled upwardly relative to the tubular member 112 in combination with, or in substitution for, the injection of the fluidic material 120 during at least a portion of the radial expansion and plastic deformation of the tubular member.

**[0010]** In several exemplary embodiments, the interface between the expansion mandrel 104 and the tubular launcher assembly 110 and/or the expandable tubular member 112 is not fluid tight. As a result, the annulus defined between the cup seals 114 and the expansion mandrel 104 within the expandable tubular member 112 is pressurized such that the resulting axial force applied to the cup seals pulls the expansion mandrel 104 and the rotary expansion device 108

through the tubular launcher assembly 110 and/or the expandable tubular member 112.

**[0011]** In several alternative embodiments, the order and/or orientation of the expansion mandrel 104 and/or rotary expansion tool 108 may be reversed.

**[0012]** In several alternative embodiments, a conventional hydro-forming device may be substituted for, or used in addition to, the expansion mandrel 104.

**[0013]** In several alternative embodiments, the expansion mandrel 104 and/or the rotary expansion tool 108 are adjustable in size.

**[0014]** In several alternative embodiments, a conventional rotary expansion tool such as, for example, as described in U.S. 6,457,532 and/or WO 02/081863 A1, the disclosures of which are incorporated herein by reference, or any one of the commercially available rotary expansion tools available from Weatherford International, Inc. may be substituted for, or used in combination with, the expansion mandrel 104.

In several alternative embodiments, the exemplary embodiments of Fig. 1 are implemented using the methods and/or apparatus disclosed one or more of the following: (1) U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, which claims priority from provisional application 60/121,702, filed on 2/25/99, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, which claims priority from provisional application 60/119,611, filed on 2/11/99, (4) U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (5) U.S. patent application serial no. 10/169,434, attorney docket no. 25791.10.04, filed on 7/1/02, which claims priority from provisional application 60/183,546, filed on 2/18/00, (6) U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (7) U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (8) U.S. patent number 6,575,240, which was filed as patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, which claims priority from provisional application 60/121,907, filed on 2/26/99, (9) U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (10) U.S. patent application serial no. 09/981,916, attorney docket no.

25791.18, filed on 10/18/01 as a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (11) U.S. patent number 6,604,763, which was filed as application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, which claims priority from provisional application 60/131,106, filed on 4/26/99, (12) U.S. patent application serial no. 10/030,593, attorney docket no. 25791.25.08, filed on 1/8/02, which claims priority from provisional application 60/146,203, filed on 7/29/99, (13) U.S. provisional patent application serial no. 60/143,039, attorney docket no. 25791.26, filed on 7/9/99, (14) U.S. patent application serial no. 10/111,982, attorney docket no. 25791.27.08, filed on 4/30/02, which claims priority from provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (15) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (16) U.S. provisional patent application serial no. 60/438,828, attorney docket no. 25791.31, filed on 1/9/03, (17) U.S. patent number 6,564,875, which was filed as application serial no. 09/679,907, attorney docket no. 25791.34.02, on 10/5/00, which claims priority from provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (18) U.S. patent application serial no. 10/089,419, filed on 3/27/02, attorney docket no. 25791.36.03, which claims priority from provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (19) U.S. patent application serial no. 09/679,906, filed on 10/5/00, attorney docket no. 25791.37.02, which claims priority from provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (20) U.S. patent application serial no. 10/303,992, filed on 11/22/02, attorney docket no. 25791.38.07, which claims priority from provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (21) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (22) U.S. provisional patent application serial no. 60/455,051, attorney docket no. 25791.40, filed on 3/14/03, (23) PCT application US02/2477, filed on 6/26/02, attorney docket no. 25791.44.02, which claims priority from U.S. provisional patent application serial no. 60/303,711, attorney docket no. 25791.44, filed on 7/6/01, (24) U.S. patent application serial no. 10/311,412, filed on 12/12/02, attorney docket no. 25791.45.07, which claims priority from provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (25) U.S. patent application serial no. 10/, filed on 12/18/02, attorney docket no. 25791.46.07, which claims priority from provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (26) U.S. patent application serial no. 10/322,947, filed on 1/22/03, attorney docket no. 25791.47.03, which

claims priority from provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (27) U.S. patent application serial no. 10/406,648, filed on 3/31/03, attorney docket no. 25791.48.06, which claims priority from provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (28) PCT application US02/04353, filed on 2/14/02, attorney docket no. 25791.50.02, which claims priority from U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001, (29) U.S. patent application serial no. 10/465,835, filed on 6/13/03, attorney docket no. 25791.51.06, which claims priority from provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001, (30) U.S. patent application serial no. 10/465,831, filed on 6/13/03, attorney docket no. 25791.52.06, which claims priority from U.S. provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001, (31) U.S. provisional patent application serial no. 60/452,303, filed on 3/5/03, attorney docket no. 25791.53, (32) U.S. patent number 6,470,966, which was filed as patent application serial number 09/850,093, filed on 5/7/01, attorney docket no. 25791.55, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (33) U.S. patent number 6,561,227, which was filed as patent application serial number 09/852,026, filed on 5/9/01, attorney docket no. 25791.56, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (34) U.S. patent application serial number 09/852,027, filed on 5/9/01, attorney docket no. 25791.57, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (35) PCT Application US02/25608, attorney docket no. 25791.58.02, filed on 8/13/02, which claims priority from provisional application 60/318,021, filed on 9/7/01, attorney docket no. 25791.58, (36) PCT Application US02/24399, attorney docket no. 25791.59.02, filed on 8/1/02, which claims priority from U.S. provisional patent application serial no. 60/313,453, attorney docket no. 25791.59, filed on 8/20/2001, (37) PCT Application US02/29856, attorney docket no. 25791.60.02, filed on 9/19/02, which claims priority from U.S. provisional patent application serial no. 60/326,886, attorney docket no. 25791.60, filed on 10/3/2001, (38) PCT Application US02/20256, attorney docket no. 25791.61.02, filed on 6/26/02, which claims priority from U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, (39) U.S.

patent application serial no. 09/962,469, filed on 9/25/01, attorney docket no. 25791.62, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (40) U.S. patent application serial no. 09/962,470, filed on 9/25/01, attorney docket no. 25791.63, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (41) U.S. patent application serial no. 09/962,471, filed on 9/25/01, attorney docket no. 25791.64, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (42) U.S. patent application serial no. 09/962,467, filed on 9/25/01, attorney docket no. 25791.65, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (43) U.S. patent application serial no. 09/962,468, filed on 9/25/01, attorney docket no. 25791.66, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (44) PCT application US 02/25727, filed on 8/14/02, attorney docket no. 25791.67.03, which claims priority from U.S. provisional patent application serial no. 60/317,985, attorney docket no. 25791.67, filed on 9/6/2001, and U.S. provisional patent application serial no. 60/318,386, attorney docket no. 25791.67.02, filed on 9/10/2001, (45) PCT application US 02/39425, filed on 12/10/02, attorney docket no. 25791.68.02, which claims priority from U.S. provisional patent application serial no. 60/343,674, attorney docket no. 25791.68, filed on 12/27/2001, (46) U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (47) U.S. utility patent application serial no. 10/516,467, attorney docket no. 25791.70, filed on 12/10/01, which is a continuation application of U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (48) PCT application US 03/00609, filed on 1/9/03, attorney docket no. 25791.71.02, which claims priority from U.S. provisional patent application serial no. 60/357,372, attorney docket no. 25791.71, filed on 2/15/02, (49) U.S. patent application serial no. 10/074,703,

attorney docket no. 25791.74, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (50) U.S. patent application serial no. 10/074,244, attorney docket no. 25791.75, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (51) U.S. patent application serial no. 10/076,660, attorney docket no. 25791.76, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (52) U.S. patent application serial no. 10/076,661, attorney docket no. 25791.77, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (53) U.S. patent application serial no. 10/076,659, attorney docket no. 25791.78, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (54) U.S. patent application serial no. 10/078,928, attorney docket no. 25791.79, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (55) U.S. patent application serial no. 10/078,922, attorney docket no. 25791.80, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (56) U.S. patent application serial no. 10/078,921, attorney docket no. 25791.81, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (57) U.S. patent application serial no. 10/261,928, attorney docket no. 25791.82, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (58) U.S. patent application serial no. 10/079,276, attorney docket no. 25791.83, filed on 2/20/02, which is a divisional of U.S. patent



number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (59) U.S. patent application serial no. 10/262,009, attorney docket no. 25791.84, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (60) U.S. patent application serial no. 10/092,481, attorney docket no. 25791.85, filed on 3/7/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (61) U.S. patent application serial no. 10/261,928, attorney docket no. 25791.86, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (62) PCT application US 02/36157, filed on 11/12/02, attorney docket no. 25791.87.02, which claims priority from U.S. provisional patent application serial no. 60/338,996, attorney docket no. 25791.87, filed on 11/12/01, (63) PCT application US 02/36267, filed on 11/12/02, attorney docket no. 25791.88.02, which claims priority from U.S. provisional patent application serial no. 60/339,013, attorney docket no. 25791.88, filed on 11/12/01, (64) PCT application US 03/11765, filed on 4/16/03, attorney docket no. 25791.89.02, which claims priority from U.S. provisional patent application serial no. 60/383,917, attorney docket no. 25791.89, filed on 5/29/02, (65) PCT application US 03/15020, filed on 5/12/03, attorney docket no. 25791.90.02, which claims priority from U.S. provisional patent application serial no. 60/391,703, attorney docket no. 25791.90, filed on 6/26/02, (66) PCT application US 02/39418, filed on 12/10/02, attorney docket no. 25791.92.02, which claims priority from U.S. provisional patent application serial no. 60/346,309, attorney docket no. 25791.92, filed on 1/7/02, (67) PCT application US 03/06544, filed on 3/4/03, attorney docket no. 25791.93.02, which claims priority from U.S. provisional patent application serial no. 60/372,048, attorney docket no. 25791.93, filed on 4/12/02, (68) U.S. patent application serial no. 10/331,718, attorney docket no. 25791.94, filed on 12/30/02, which is a divisional U.S. patent application serial no. 09/679,906, filed on 10/5/00, attorney docket no. 25791.37.02, which claims priority from provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (69) PCT application US 03/04837, filed on 2/29/03, attorney docket no. 25791.95.02, which claims priority from U.S. provisional patent application serial no. 60/363,829, attorney docket no. 25791.95, filed on 3/13/02, (70) U.S. patent application serial no. 10/261,927, attorney docket no. 25791.97, filed on

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10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (71) U.S. patent application serial no. 10/262,008, attorney docket no. 25791.98, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (72) U.S. patent application serial no. 10/261,925, attorney docket no. 25791.99, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (73) U.S. patent application serial no. 10/199,524, attorney docket no. 25791.100, filed on 7/19/02, which is a continuation of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (74) PCT application US 03/10144, filed on 3/28/03, attorney docket no. 25791.101.02, which claims priority from U.S. provisional patent application serial no. 60/372,632, attorney docket no. 25791.101, filed on 4/15/02, (75) U.S. provisional patent application serial no. 60/412,542, attorney docket no. 25791.102, filed on 9/20/02, (76) PCT application US 03/14153, filed on 5/6/03, attorney docket no. 25791.104.02, which claims priority from U.S. provisional patent application serial no. 60/380,147, attorney docket no. 25791.104, filed on 5/6/02, (77) PCT application US 03/19993, filed on 6/24/03, attorney docket no. 25791.106.02, which claims priority from U.S. provisional patent application serial no. 60/397,284, attorney docket no. 25791.106, filed on 7/19/02, (78) PCT application US 03/13787, filed on 5/5/03, attorney docket no. 25791.107.02, which claims priority from U.S. provisional patent application serial no. 60/387,486, attorney docket no. 25791.107, filed on 6/10/02, (79) PCT application US 03/18530, filed on 6/11/03, attorney docket no. 25791.108.02, which claims priority from U.S. provisional patent application serial no. 60/387,961, attorney docket no. 25791.108, filed on 6/12/02, (80) PCT application US 03/20694, filed on 7/1/03, attorney docket no. 25791.110.02, which claims priority from U.S. provisional patent application serial no. 60/398,061, attorney docket no. 25791.110, filed on 7/24/02, (81) PCT application US 03/20870, filed on 7/2/03, attorney docket no. 25791.111.02, which claims priority from U.S. provisional patent application serial no. 60/399,240, attorney docket no. 25791.111, filed on 7/29/02, (82) U.S. provisional patent application serial no. 60/412,487, attorney docket no. 25791.112, filed on 9/20/02, (83) U.S. provisional patent application serial no. 60/412,488, attorney docket no. 25791.114, filed on

9/20/02, (84) U.S. patent application serial no. 10/280,356, attorney docket no. 25791.115, filed on 10/25/02, which is a continuation of U.S. patent number 6,470,966, which was filed as patent application serial number 09/850,093, filed on 5/7/01, attorney docket no. 25791.55, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (85) U.S. provisional patent application serial no. 60/412,177, attorney docket no. 25791.117, filed on 9/20/02, (86) U.S. provisional patent application serial no. 60/412,653, attorney docket no. 25791.118, filed on 9/20/02, (87) U.S. provisional patent application serial no. 60/405,610, attorney docket no. 25791.119, filed on 8/23/02, (88) U.S. provisional patent application serial no. 60/405,394, attorney docket no. 25791.120, filed on 8/23/02, (89) U.S. provisional patent application serial no. 60/412,544, attorney docket no. 25791.121, filed on 9/20/02, (90) PCT application PCT/US03/24779, filed on 8/8/03, attorney docket no. 25791.125.02, which claims priority from U.S. provisional patent application serial no. 60/407,442, attorney docket no. 25791.125, filed on 8/30/02, (91) U.S. provisional patent application serial no. 60/423,363, attorney docket no. 25791.126, filed on 12/10/02, (92) U.S. provisional patent application serial no. 60/412,196, attorney docket no. 25791.127, filed on 9/20/02, (93) U.S. provisional patent application serial no. 60/412,187, attorney docket no. 25791.128, filed on 9/20/02, (94) U.S. provisional patent application serial no. 60/412,371, attorney docket no. 25791.129, filed on 9/20/02, (95) U.S. patent application serial no. 10/382,325, attorney docket no. 25791.145, filed on 3/5/03, which is a continuation of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (96) U.S. patent application serial no. 10/624,842, attorney docket no. 25791.151, filed on 7/22/03, which is a divisional of U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, which claims priority from provisional application 60/119,611, filed on 2/11/99, (97) U.S. provisional patent application serial no. 60/431,184, attorney docket no. 25791.157, filed on 12/5/02, (98) U.S. provisional patent application serial no. 60/448,526, attorney docket no. 25791.185, filed on 2/18/03, (99) U.S. provisional patent application serial no. 60/461,539, attorney docket no. 25791.186, filed on 4/9/03, (100) U.S. provisional patent application serial no. 60/462,750, attorney docket no. 25791.193, filed on 4/14/03, (101) U.S. provisional patent application serial no. 60/436,106, attorney docket no. 25791.200, filed on 12/23/02, (102) U.S. provisional patent application serial no. 60/442,942, attorney docket no. 25791.213, filed on 1/27/03, (103) U.S. provisional patent application serial no. 60/442,938, attorney docket no. 25791.225, filed on

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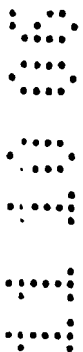
1/27/03, (104) U.S. provisional patent application serial no. 60/418,687, attorney docket no. 25791.228, filed on 4/18/03, (105) U.S. provisional patent application serial no. 60/454,896, attorney docket no. 25791.236, filed on 3/14/03, (106) U.S. provisional patent application serial no. 60/450,504, attorney docket no. 25791.238, filed on 2/26/03, (107) U.S. provisional patent application serial no. 60/451,152, attorney docket no. 25791.239, filed on 3/9/03, (108) U.S. provisional patent application serial no. 60/455,124, attorney docket no. 25791.241, filed on 3/17/03, (109) U.S. provisional patent application serial no. 60/453,678, attorney docket no. 25791.253, filed on 3/11/03, (110) U.S. patent application serial no. 10/421,682, attorney docket no. 25791.256, filed on 4/23/03, which is a continuation of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (111) U.S. provisional patent application serial no. 60/457,965, attorney docket no. 25791.260, filed on 3/27/03, (112) U.S. provisional patent application serial no. 60/455,718, attorney docket no. 25791.262, filed on 3/18/03, (113) U.S. patent number 6,550,821, which was filed as patent application serial no. 09/811,734, filed on 3/19/01, (114) U.S. patent application serial no. 10/436,467, attorney docket no. 25791.268, filed on 5/12/03, which is a continuation of U.S. patent number 6,604,763, which was filed as application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, which claims priority from provisional application 60/131,106, filed on 4/26/99, (115) U.S. provisional patent application serial no. 60/459,776, attorney docket no. 25791.270, filed on 4/2/03, (116) U.S. provisional patent application serial no. 60/461,094, attorney docket no. 25791.272, filed on 4/8/03, (117) U.S. provisional patent application serial no. 60/461,038, attorney docket no. 25791.273, filed on 4/7/03, (118) U.S. provisional patent application serial no. 60/463,586, attorney docket no. 25791.277, filed on 4/17/03, (119) U.S. provisional patent application serial no. 60/472,240, attorney docket no. 25791.286, filed on 5/20/03, (120) U.S. patent application serial no. 10/619,285, attorney docket no. 25791.292, filed on 7/14/03, which is a continuation-in-part of U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (121) U.S. utility patent application serial no. 10/418,688, attorney docket no. 25791.257, which was filed on 4/18/03, as a division of U.S. utility patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (122) PCT patent application serial no. PCT/US2004/006246, attorney docket no. 25791.238.02, filed

on 2/26/2004, (123) PCT patent application serial no. PCT/US2004/007711, attorney docket no. 25791.253.02, filed on 3/11/2004, (124) PCT patent application serial no. PCT/US2004/008170, attorney docket no. 25791.40.02, filed on 3/15/2004, (125) PCT patent application serial no. PCT/US2004/06246, attorney docket no. 25791.238.02, filed on 2/26/2004, (126) PCT patent application serial number PCT/US2004/08170, attorney docket number 25791.40.02, filed on 3/15/04, (127) PCT patent application serial number PCT/US2004/08171, attorney docket number 25791.236.02, filed on 3/15/04, (128) PCT patent application serial number PCT/US2004/08073, attorney docket number 25791.262.02, filed on 3/18/04, (129) PCT patent application serial number PCT/US2004/07711, attorney docket number 25791.253.02, filed on 3/11/2004, (130) PCT patent application serial number PCT/US2004/029025, attorney docket number 25791.260.02, filed on 3/26/2004, (131) PCT patent application serial number PCT/US2004/010317, attorney docket number 25791.270.02, filed on 4/2/2004, (132) PCT patent application serial number PCT/US2004/010712, attorney docket number 25791.272.02, filed on 4/6/2004, (133) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004, (134) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on 4/15/2004, (135) U.S. provisional patent application serial number 60/495056, attorney docket number 25791.301, filed on 8/14/2003, (136) U.S. provisional patent application serial number 60/600679, attorney docket number 25791.194, filed on 8/11/2004, (137) PCT patent application serial number PCT/US2005/027318, attorney docket number 25791.329.02, filed on 7/29/2005, (138) PCT patent application serial number PCT/US2005/028936, attorney docket number 25791.338.02, filed on 8/12/2005, (139) PCT patent application serial number PCT/US2005/ 028669, attorney docket number 25791.194.02, filed on 8/11/2005, (140) PCT patent application serial number PCT/US2005/028453, attorney docket number 25791.371, filed on 8/11/2005, (141) PCT patent application serial number PCT/US2005/028641, attorney docket number 25791.372, filed on 8/11/2005, (142) PCT patent application serial number PCT/US2005/028819, attorney docket number 25791.373, filed on 8/11/2005, (143) PCT patent application serial number PCT/US2005/028446, attorney docket number 25791.374, filed on 8/11/2005, (144) PCT patent application serial number PCT/US2005/028642, attorney docket number 25791.375, filed on 8/11/2005, (145) PCT patent application serial number PCT/US2005/028451, attorney docket number 25791.376, filed on 8/11/2005, and (146). PCT patent application serial number PCT/US2005/028473, attorney docket number 25791.377, filed on 7/29/2005, the disclosures of which are incorporated herein by reference.

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Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the claims.



**CLAIMS:**

1. An apparatus for radially expanding and plastically deforming a tubular member, comprising:
  - a first expansion device for controllably straining the tubular member; and
  - a second expansion device for controllably stressing the tubular member,the first and second expansion devices being coupled for conjoint movement through substantially the entire length of the tubular member to be radially expanded and plastically deformed.
2. The apparatus of claim 1, further comprising:
  - a tubular support member defining a first passage;
  - wherein the first expansion device comprises a tubular expansion cone defining a second passage coupled to the tubular support member;
  - wherein the apparatus further comprises a fluid driven motor coupled to the tubular expansion cone comprising an inlet;
  - wherein the second expansion device comprises a rotary expansion device coupled to the output shaft of the fluid driven motor;
  - wherein the first passage is operably coupled to the second passage; and
  - wherein the second passage is operably coupled to the inlet of the fluid driven motor.
3. The apparatus of claim 1, further comprising a motor coupled to the first expansion device for rotating the second expansion device relative to the first expansion device.
4. The apparatus of claim 1, further comprising:
  - a motor coupled to the first expansion device for displacing the second expansion device relative to the first expansion device.
5. The apparatus of claim 1, wherein the interface between the first expansion device and the tubular member is not fluid tight; and the apparatus further comprising:
  - means for pulling the first expansion device through the tubular member.
6. The apparatus of claim 1, further comprising a hydroforming device for radially expanding and plastically deforming the tubular member.

7. The apparatus of claim 1, wherein at least one of the first and second expansion devices is adjustable in size.
8. The apparatus of claim 1, wherein the tubular member comprises a pipeline.
9. The apparatus of claim 1, wherein the tubular member comprises a structural support.
10. The apparatus of claim 1, wherein the interface between the first expansion device and the tubular member is not fluid tight;  
 wherein the apparatus further comprises:  
 means for pulling the first expansion device through the tubular member; and  
 a hydroforming device for radially expanding and plastically deforming the tubular member;  
 wherein at least one of the first and second expansion devices is adjustable in size; and  
 wherein the tubular member comprises at least one of a pipeline or a structural support.
11. A method of radially expanding and plastically deforming a tubular member, comprising:  
 controllably straining the tubular member; and  
 controllably stressing the tubular member,  
 the controllably straining and controllably stressing steps being simultaneously performed progressively along substantially the entire length of the tubular member to be radially expanded and plastically deformed.
12. The method of claim 11, wherein controllably stressing the tubular member is performed by:  
 controllably stressing a longitudinal portion of the tubular member before controllably straining the longitudinal portion of the tubular member.
13. The method of claim 11, further comprising:  
 radially expanding and plastically deforming the tubular member using fluidic pressure.
14. The method of claim 11, wherein the tubular member comprises a pipeline.



15. The method of claim 11, wherein the tubular member comprises a structural support.
16. The method of claim 11, wherein controllably stressing the tubular member is performed by:
- controllably stressing a longitudinal portion of the tubular member after controllably straining the longitudinal portion of the tubular member;
  - wherein the method further comprises radially expanding and plastically deforming the tubular member using fluidic pressure; and
  - wherein the tubular member comprises at least one of a pipeline or structural support.
17. The method of Claim 11, wherein controllably stressing the tubular member is performed by:
- controllably stressing a longitudinal portion of the tubular member after controllably straining the longitudinal portion of the tubular member.
18. A system for radially expanding and plastically deforming a tubular member, comprising:
- means for controllably straining the tubular member;
  - means for controllably stressing the tubular member; and
  - means for linking the means for controllably straining and the means for controllably stressing for conjoint movement through substantially the entire length of the tubular member to be radially expanded and plastically deformed.
19. The system of Claim 18, wherein means for controllably stressing the tubular member comprises:
- means for controllably stressing a longitudinal portion of the tubular member before controllably straining the longitudinal portion of the tubular member.
20. The system of Claim 18, wherein means for controllably stressing the tubular member comprises:
- means for controllably stressing a longitudinal portion of the tubular member after controllably straining the longitudinal portion of the tubular member.

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**We shall be pleased to provide further advice  
on specific problems relating to any of the above topics**

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